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In the United States Patent and Trademark Office

Application Number: 10/692,755
Applicant: DR. RUSI TALEYARKHAN
Examiner: DR. RICARDO PALABRICA
Art Unit: 3663

February 27, 2009

FILING OF THE APPEAL BRIEF

VIA FAX 571 273 8300
Assistant Commissioner of Patents
Washington, DC 20231

Sir,

The appeal brief for the Appeal to the Board of Appeals for the above application is attached and contains 76 pages.

Very respectfully,

Dr. Arjuna I. Rajasingham
Chairman & Chief Executive
MMILLENNIUMM ENERGY CORPORATION

Att:
Appeal Brief 76 pages

Applicant: Rusi Taleyarkhan

Application number: 10/692,755

Filing Date: 10/27/2003

Title of Invention: Methods and Apparatus to induce D-D and D-T reactions

Examiner: Rick Palabrica

Art Unit: 3663

Title: APPEAL BRIEF

(B) Table of Contents page(s);

(C) Real party in interest page(s);

MMILLENNIUMM ENERGY CORPORATION

MMILLENNIUMM GROUP INC.

DR. RUSI TALEYARKHAN

(D) Related appeals and interferences page(s);

NONE

(E) Status of claims page(s);

<u>Claims:</u>

1.(Withdrawn).

2.(Withdrawn)

3. (Withdrawn)

4. (Withdrawn)

5.(Withdrawn

6.(Withdrawn)

7.(Withdrawn)

8.(Withdrawn)

9. (Withdrawn)

10.(Withdrawn)

11.(Withdrawn)

12 .(Withdrawn)

13. (Withdrawn)

14. (Withdrawn)

15. (Withdrawn)

16.(Withdrawn)

17.(Withdrawn)

18. (Withdrawn)

19. (Withdrawn)

20.(Withdrawn)

21. (Withdrawn)

22. (Cancelled)

23. (Cancelled)

24. (Cancelled)

25. (Cancelled)

26. (Withdrawn)

27. (Cancelled)

28. (Cancelled)

29. (Cancelled)

30 (Cancelled)

31 (Cancelled)

32 (Cancelled)

33 (Cancelled)

34. (Rejected)

35. (Rejected)

36. (Rejected)

37. (Rejected)

38. (Rejected)

39. (Rejected)

40. (Rejected)

41. (Rejected)

42. (Rejected)

43. (Rejected)

44. (Rejected)

45. (Rejected)

46. (Rejected)

47. (Rejected)

(F) Status of amendments page(s);

The applicant filed an amendment to claims 34 and 47, to correct the inadequate antecedent between claim 34 and Claim 44, and to conform to an elected species (Method) in claim 47. Claim 48, was added to address the comments by the examiner with regard to an optional step in the claimed methods of the invention. A grammatical error in claim 34 was also corrected.

The applicant understands that the amendments will not be entered.

Affidavits filed were not acknowledged by the Office. New Affidavit has been filed.

34. (Currently amended). A method for producing thermonuclear nuclear fusion, comprising the steps of: providing a working liquid enriched with molecules comprising isotopic D or T atoms ~~comprising molecules~~; placing at least a portion of said liquid into a tension state, a maximum tension in said tension state being below the cavitation threshold of said liquid, said tension state imparting stored mechanical energy into said liquid portion; directing fundamental particles ~~nucleating agents comprising at least one of: neutrons, photons, alpha particles and fission products~~, at said liquid portion when said liquid portion is in said tension state, said nucleating agents having sufficient energy for nucleating a plurality of bubbles substantially filled with vapor from said liquid, said bubbles substantially filled with vapor having an as nucleated bubble radius greater than a critical bubble radius of said liquid; growing said bubbles; and imploding said bubbles substantially filled with vapor, wherein a resulting temperature obtained from energy released from said implosion is sufficient to induce a nuclear fusion reaction of said isotopic D or T atom comprising molecules in said liquid portion.

47. (currently amended) A method ~~An apparatus~~ for producing thermonuclear fusion, comprising the steps of : filling a chamber with ~~containing~~ a high accommodation coefficient liquid; ~~a means for~~ inducing tension in said high accommodation coefficient liquid; directing a nucleating agent comprising at least one of: neutrons, alpha particles, photons and fission products to said chamber; ~~a means for~~ enhancing the size of the nucleated bubbles in tension

to a volume greater than a predetermined volume before inducing controlled implosion; thereby producing thermonuclear fusion.

48. (new) A method of claim 34, wherein the working liquid is de-gassed prior to being put in a tension state.

(G) Summary of claimed subject matter page(s);

Note: The appellant submits that the responses are given in relation to the July 23, 2005 Published Application by paragraph. The line numbers quoted are in relation to the noted paragraphs.

Claim 34.

A method to produce thermo-nuclear fusion in the local environment of vapor bubbles in the body of their parent liquid.

Comprising the steps of:

Step1.

> *"providing a working liquid enriched with molecules comprising isotopic D or T atoms"*

Figure 1 (item 124)

Para. 22 (line 12); Para. 73 (lines 2-3); Para. 76 (lines 2, 3, 8)

Step2.

> *"placing at least a portion of said liquid into a tension state, a maximum tension in said tension state being below the cavitation threshold of said liquid, said tension state imparting stored mechanical energy into said liquid portion"*

Para.15 (lines 3-6); Para.18 (lines: 2-5); Para. 26 (lines 3-7); Para. 178 (lines 1-3).

Step3.

> *"directing fundamental particles , at said liquid portion when said liquid portion is in said tension state, said nucleating agents having sufficient energy for nucleating a plurality of bubbles substantially filled with vapor from said liquid,*

said bubbles substantially filled with vapor having an as nucleated bubble radius greater than a critical bubble radius of said liquid"

Fig.1 (item 150); Fig. 3c; Fig. 6 (item 633)

Para. 15 (lines 8-11); Para. 18 (lines 6-8); Para 21 (lines 1-2); Para. 55 (lines 3-4); Para. 129, Para. 132 (lines 3-7); Para. 166 (lines 1-3); Para 71; Para 176 (1-3).

Step4.

"growing said bubbles"

Fig. 3c

Para 15 (lines 9-11); Para 26 (lines 8-9); Para 33; Para 57 (lines 3, 8-9); Para 58 (lines 1-2); Para 63 (lines 3-5); Para. 64.

Step5.

"imploding said bubbles substantially filled with vapor, wherein a resulting temperature obtained from energy released from said implosion is sufficient to induce a nuclear fusion reaction of said isotopic D or T atom comprising molecules in said liquid portion"

Para 15 (13-17), para 18 (lines 8-11), para 26 (lines 11-14), para 28 (lines 8-11)

Claim 47.

Step1.

"filling a chamber with a high accommodation coefficient liquid"

Fig. 1 (item 124)

Para 66, Para 74, Para 107 (1-4)

Step2.

"inducing tension in said high accommodation coefficient liquid"

Para 15 (3-6), Para 18 (2-5), Para 178 (1-3), Para 74, Para 190.

Step3.

"directing a nucleating agent comprising at least one of: neutrons, alpha particles, photons and fission products to said chamber "

Fig.1 (item 150); Fig. 3c; Fig. 6 (item 633)

Para. 15 (lines 8-11); Para. 18 (lines 6-8); Para 21 (lines 1-2); Para. 55 (lines 3-4); Para. 129, Para 130 (1-4), Para. 132 (lines 1-3); Para 157 (1-4), Para. 166 (lines 1-3); Para 71; Para 176 (2-3).

Step4.

"enhancing the size of the nucleated bubbles in tension to a volume greater than a predetermined volume before inducing controlled implosion"

Fig. 3a, Fig. 3c

Para 64, Para 67, Para 72 (lines 8-15), Para 120, Para 133.

(H) Grounds of rejection to be reviewed on appeal page(s);

1. Whether claims 34 -46 are unpatentable under 35 U.S.C. 101 for lack of utility

2. Whether claims 34 -46 are unpatentable under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement.

3. In claim 34 "placing at least a portion of said liquid into a tension state, a maximum tension in said tension state being below the cavitation threshold of said liquid." , whether there is adequate description or enabling disclosure as to how and in what manner one can determine: a) that a portion of the liquid is in the so-called tension state; b) the maximum tension in a portion of the liquid in a tension state; and c) that the maximum tension is below the cavitation threshold of the liquid.

4. In Claim 34 "imploding said bubbles substantially filled with vapor." whether there is either an adequate description or enabling disclosure as to how and in what manner one: a) can determine when a bubble has been substantially filled with vapor; b)identify which of the bubbles that are allegedly substantially filled with vapor; and c) how many of these bubbles to implode to induce a nuclear fusion reaction.

5. In Claim 42 "synchronizing neutron impact with a location in said liquid having a predetermined liquid tension level." whether there is either an adequate description or enabling disclosure as to how and in what manner one: a) can determine the occurrence of an impact of the neutron with the pre-tensioned liquid; b) synchronizes the neutron impact with a location in said liquid; c) determines which specific location to direct the impact of the neutron.

6. In claim 34, whether the deletion of the degassing step is the addition of new matter.

7. In Claim 44, whether the recitation of "said fundamental particles" in lines 1 and 2 results in an insufficient antecedent basis for this claim.

8. In claim 46, whether the term "high accommodation coefficient liquid" is a relative term which renders the claim Indefinite. As the term "high" which is not defined by the claim, and the specification does not provide a standard for ascertaining the requisite degree, whether

one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

9. In claims 34, 35, 37-40, 44, 45, whether under 35 U.S.C. 102(b) are anticipated by Margulis (RU 2096934)

10. In claim 36, whether under 35 U.S.C. 102(b) are anticipated by Margulis (RU 2096934) with regard to heat exchangers.

11. In claims 42 whether under 35 U.S.C. 102(b) are anticipated by Margulis (RU 2096934)

12. In claims 34, 35, 37-40, 44, 45 whether under 35 U.S.C. 102(b) are anticipated by Lipson et ai., "Initiation of fusion reactions in media containing deuterium by cavitation," Soviet Physics: Technical Physics 37 (1992) .

13. In claims 36 whether under 35 U.S.C. 102(b) are anticipated by Lipson et ai., "Initiation of fusion reactions in media containing deuterium by cavitation," Soviet Physics: Technical Physics 37 (1992) .

14. In claims 42 whether under 35 U.S.C. 102(b) are anticipated by Lipson et ai., "Initiation of fusion reactions in media containing deuterium by cavitation," Soviet Physics: Technical Physics 37 (1992) .

15. Whether claim 41, is patentable over either Margulis or Lipson.

16. Whether claim 43 and 46, are patentable over either Margulis or Lipson, in light of Didenko et al.

17. Whether the duplicate claim 34 vs 44 can be overcome with the proposed amendment.

18. Whether Claim 47 is rejected as directed to a non-elected invention.

(I) Argument page(s);

1. Whether claims 34 -46 are unpatentable under 35 U.S.C. 101 for lack of utility

The disclosure states that the invention produces excess neutrons and Tritium as the consequence of thermo-nuclear fusion. Affidavit from Xu. replicates this phenomenon in independent experiments.

References in disclosure:

1. Figs. 3e, 8, 10, 11, 12,13,14;

2. Para. 17;

3. para 24(line1);

4. para 58(line10);

5. para 94 (lines 7-8);

6. para 116(line1);

7. Para 121 (line 3);

8. Para 208;

9. Para 219;

10. Para 222;

11. Para 226;

12. Para 227.

The Utility of Tritium and neutron sources are well established in the background art but also noted in the disclosure in para 24 of the published application, and in Xu's affidavit (para. 8).

2. Whether claims 34 -46 are unpatentable under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement.

In general, the fusion of deuterium(D)-deuterium(D) atoms is unequivocally established in the literature (Gross, 1984) to lead to one of two almost equally probable nuclear reactions. These are:

- The production of a 1.01 MeV tritium (T) nucleus and a 3.02 MeV proton.
- The production of a 0.82 MeV helium-3 (^3He) nucleus and a 2.45 MeV neutron.

For the thermonuclear bubble fusion system, the tell-tale signatures of the event involve the measurement of 2.45 MeV neutrons which must be time-correlated with the time of bubble implosion (i.e., when the conditions are compressed and hot and light flashes are generated), the generation of gamma photons commensurate with neutron interactions with structural atoms, together with the generation of T nuclei at rates that are similar in rate to that for neutron production.

The Appelant submits the following to establish probity and enablement.

I. In acoustic inertial confinement bubble nuclear fusion experiments (Taleyarkhan et al., 2002, 2004, 2006), all of which used the teachings of 10/692,755 for enablement, the evidence for D-D fusion includes the following key findings of fact:

1. A statistically significant (4 to 5 Standard Deviations) production of tritium nuclei [Science (2002) – Fig. 3; Phys.Rev.E (2004)-Fig.11];
2. A statististically significant (4 to 25 Standard Deviations) number of 2.45 MeV neutrons [Science(2002)-Fig.4; Phys.Rev.E (2004)-Fig.8; Phys.Rev.Ltr (2006)-Fig.4];
3. An approximately equal number of D-D neutrons and T nuclei produced during any given experiment [Science(2002); Phys.Rev.E (2004)];
4. The generation of D-D neutrons time correlated with sonoluminescence (SL) flashes during deuterated bubble cluster implosions [Science(2002)-Fig.5; Phys.Rev.E (2004)-Fig.7];
5. The subsequent (to neutron and SL) emission of statistically significant quantities of gamma rays due to D-D neutron capture in hydrogen and other atoms of surrounding structures and in the detector; the ratio of gammas to neutrons being about 0.05 to about 0.15, and the energy of the gamma rays being ~ 2 MeV as to be anticipated [Phys.Rev.E (2004)-Figs.9,10];
6. The attainment of null results (i.e., no neutron, gamma or tritium emissions) for corresponding control experiments under identical conditions but with the *only variation being change of the D atoms in test liquids to H atoms* [Science (2002), Phys.Rev.E (2004), Phys.Rev.Ltr (2006);
7. The consistency of the experimentally-observed results of neutrons and tritium with theory which, after considering all key physical phenomena associated with growth and implosion dynamics, reveal and predict conditions required for thermonuclear fusion (i.e., 1000+ GPa compression pressures and ~ 10^8 K plasma states) to occur only under the conditions of successful experiments. The same theoretical framework predicts non-attainment of such conditions for non-ideal thermal hydraulic conditions, as well as for low-accommodation coefficient fluids such as heavy water for similar experiment

conditions – an aspect which is consistent with experimental findings, [Phys. Fluids (2005)-Fig.13, Science (2002)-Fig. 6];

8. The verification and confirmation of the neutron and tritium emission data by unaffiliated groups [Nucl.Engr.Design (2005); NURETH-11 (2005); Trans.Amer.Soc.(2006); Int.Fus.EnergyMtg.(2006); Bugg Report (2006); Public Demonstration Testomonials (2006)];
9. The consistency of neutron emission spectra from 5 separate reports with validated nuclear infrastructure methodologies utilizing state-of-art Monte-Carlo 3-D nuclear particle transport simulation tools (MCNP5 and SCINFUL) developed under U.S. DoE sponsorship at Los Alamos National Laboratory and Oak Ridge National Laboratory – as evidenced in Nucl. Engr. Des.(2008) – Figs. 6, 7, 9, 11]; and,
10. Testimonials of successful demonstrations on two separate occasions to collection of industry, government and academic bodies [IDI testimonials, 2006)].

II. Three affidavits confirming replications of the invention by three un-related and un-connected scientist, each of ordinary skill in the Art. These three Affidavits have been submitted and are of record (Please see Evidence appendix) .

The detailed Affidavit of Dr. Xu (para. 3) defines an independent replication of the invention enabled by the disclosures of 10/692,755, in a different location and organization with independently assembled apparatus.

III. The following evidence is further theoretical and experimental support for enablement of the invention. The examiner rejects this evidence as the results were published after the filing date.

A. Three independent academic papers defining the results obtained in replication experiments (corresponding to Affidavits of II. above) .

> Three independent replications of published sonofusion results (Nuclear Engineering and Design journal paper, Vol. 235, pp.1317-1324 by Xu et al., 2005; Archives of Trans. American Nuclear Society, Vol. 95, pp. 736-737, by Forringer et al., 2006; Le Tourneau University, Texas, Press Release, 2006; and the Bugg, W confirmation report dated June 9, 2006 to Purdue University of 2006) of the present invention. Proof of reproducibility and repeatability and confirmation of successful fusion signals attainment following the apparatus and operations of this 10/692,755 Application from published documents were reproduced for the examiner.

These are three successful replications of the invention as filed. These replications used the same methods and design of apparatus of the present invention. (Section II. presents affidavits

of these successful replications). Therefore it provides *additional* clear probity for the present invention.

The appellant submits that nothing in the observable ambient universe that could affect this experiment is known to have changed between the date of filing and this duplicate experiment, and the replicators were of ordinary skill in the Art, and therefore the results provide *additional* clear probity for the invention.

B. The theoretical foundation for super-compression-induced thermonuclear fusion for the experimental conditions of the method used for the current application. This theoretical foundation takes into account all relevant physics and chemistry of the condition. It has passed worldwide peer reviews and validated by experts as being on sound theoretical foundations and published in the prestigious journal Physics of Fluids (Nigmatulin et al., 2005). This theoretical foundation when applied specifically to the method of the present invention confirms thermonuclear conditions (see Fig. 13 of the paper by Nigmatulin et al., 2005 – Physics of Fluids, Vol.17, 107106, 2005) with temperatures and pressures reaching in the range of 10^8K, and 1000+ Mbar, respectively – convincingly thermonuclear fusion conditions.

This is a theoretical foundation for super-compression-induced thermonuclear fusion for the experimental method and apparatus of the present invention. Published in a peer reviewed Journal. This theoretical result *by design* addresses the methods and apparatus of the present invention.

The appellant submits that the theoretical result by design considers the apparatus and method of the present invention and therefore the time of publication of the results do not affect the additional probity and enablement that this theoretical study provides.

C. Findings (Fig. 7c) in the premier journal Physical Review E, Vol. 69, 036109-1 to 11, by Taleyarkhan et al., 2004 that demonstrates experimentally that D-D fusion neutrons of 2.45 MeV in energy as required for thermonuclear fusion are emitted in a time –correlated manner with the emission of sonoluminescence (SL) light flashes demonstrating that the fusion reactions are occurring under hot, compressed conditions for the method and apparatus of this present invention application.

This is an experimental study reported in a reputable peer reviewed Journal that further supports enablement of the method and apparatus of the present invention for producing 2.45MeV neutrons required for nuclear fusion, in a correlated manner to the emission of sonoluminescense light flashes. The approach uses the *identical apparatus as noted in the invention* with the *exception of more sophisticated neutron detection approaches to get an even better statistically significant result*.

With regard to this support for probity and enablement, the examiner argues further, that D-D reactions were an non elected species and therefore this result is irrelevent. (The D-D reaction case was a non elected species with traverse) However, the Appellent submits that even if the examiner limits consideration to the elected part of the invention, a D-D reaction envelopes the conditions for a D-T reaction and provides for the record art that establishes factual

experimental underpinnings. (reference: "Gross., R. A., 1984 "Fusion Energy" John Wiley & Sons.) Therefore, the applicant submits that the D-T reactions will occur if conditions for D-D reactions are provided as indicated in the Response of 2008-5-21 as experimental evidence of this reaction phenomenon.

Therefore in this result is further support of probity and enablement as nothing in the observable ambient universe that could affect this experiment is known to have changed between the date of filing and this duplicate experiment.

IV. Furthermore, the applicant has provided in the Appendix, yet another *additional* confirmation for the validity of the thermo-nuclear fusion results " Modeling Analysis and prediction of neutron emission spectra from acoustic cavitation bubble fusion experiments" Nuclear Engineering and Design 238 (2008, 2779-2791).

V. Moreover, further support is provided in the paper on theoretical foundations "The Analysis of Bubble Implosion Dynamics" Supplement #2 (Reference 25 in the IDS) and as published in Science: www. Sciencemag.org/cgi/content/full/295/5561/1868/DC1.

3. In claim 34 "placing at least a portion of said liquid into a tension state, a maximum tension in said tension state being below the cavitation threshold of said liquid." , whether there is adequate description or enabling disclosure as to how and in what manner one can determine: a) that a portion of the liquid is in the so-called tension state; b) the maximum tension in a portion of the liquid in a tension state; and c) that the maximum tension is below the cavitation threshold of the liquid.

The appellant respectfully submits that:

i. There exists a tension state for liquids achievable with tensile forces on the target volume of the liquids. For example even in nature mechanical motion of vascular passages of plants lead to liquid in tension. (Reference: Scholander., P. F., "Sap pressure in vascular plants" Science Volume 18, pp 339-345 16 April 1965.)

ii. Therefore a portion of the liquid may be reduced to the tensioned state by applying a tensile force to the container walls that is by design in contact with the liquid. Such a force may be effected by a mechanical device as in the present invention that may be centrifugal force or oscillations of the wall by an electro-mechanical device. Such force enabling by these two phenomena are well established in the background art. The magnitude of the noted force can be increased by design to ensure that the liquid is at a desired level of the tension state.

iii. The specification teaches the regions of the liquid that are in tension as a result of the apparatus design. For example originally filed Specification page 47 line 15-18 and Page 39 lines 19-21. (para [0135] and para [0167] as published).

iv. There exists a cavitation threshold for such tensioned liquids by audible and visible inspection at adequate drive power of the mechanical force in the presence of nucleating particles.
v. The method or apparatus of the invention can achieve and exceed such a cavitation threshold *by design* as in 3.2 above, as a result of 3.3 above.

Therefore the appellant respectfully submits that the enablement requirement is met with the background art.

4. In Claim 34 "imploding said bubbles substantially filled with vapor." whether there is either an adequate description or enabling disclosure as to how and in what manner one: a) can determine when a bubble has been substantially filled with vapor; b)identify which of the bubbles that are allegedly substantially filled with vapor; and c) how many of these bubbles to implode to induce a nuclear fusion reaction.

The appellant respectfully submits that:

i. The background Art is replete with exposition that any fluid will exert a vapor pressure in an adjoining space and therefore such bubbles are substantially filled with vapor of the parent liquid as disclosed. As there are no other liquids in contact with the bubble surface therefore there is no other vapor pressure exerted. Moreover, considering that there is no attempt to intentionally dissolve gases in the parent liquid the resulting partial pressures if any such gases are small, however as the parent liquid at some point may have had a surface open to a gas such as the constituent gases of the atmosphere, there is likely to be some – even minute quantities -- of preexisting dissolved gas in the parent fluid. Therefore the applicant submits that all such bubbles are substantially filled with vapor of the parent liquid.
ii. One or more such imploding bubbles create nuclear fusion as substantiated in the experimental observation results of the disclosure. The nature of bubbles that create nuclear fusion are defined in the Specification Page 18 lines 20-21 page 19 lines 1-4.

Therefore the appellant respectfully submits that the disclosure in conjunction with the background art is enabling.

5. In Claim 42 "synchronizing neutron impact with a location in said liquid having a predetermined liquid tension level." whether there is either an adequate description or enabling disclosure as to how and in what manner one: a) can determine the occurrence of an impact of the neutron with the pre-tensioned liquid; b) synchronizes the neutron impact with a location in said liquid; c) determines which specific location to direct the impact of the neutron.

The appellant respectfully submits that the specification discloses the production of tensioning of the liquid in synchronization with the nucleating particles. Fig 3, Page 21 lines 8-15, Page 25 lines 3-20, of the original Specification.

The nucleating particles are directed in the direction of the chamber and therefore those that reach the liquid during the above tension state are capable of nucleating 10-100nm size bubbles. It is established in the background art that nucleating particles can nucleate bubbles of this size in meta-stable liquids. Reference: Glaser. D. A., Phys. Rev., Vol.87, 665, 1952.

Therefore the appellant respectfully submits that the disclosure in conjunction with the background art is enabling.

6. In claim 34, whether the deletion of the degassing step is the addition of new matter.

The examiner rejects claims 34-46 as he notes that on claim 34, as amended: applicant has deleted the step, "degassing said liquid to reduce a dissolved gas content therein, wherein said dissolved gas is removed using an applied vacuum." Note the following passages in the specification that demonstrate criticality of the degassing step in the exercise of the claimed invention:

"To minimize the effect of gas cushioning during implosive collapse, the working liquid can be degassed, a priori. *Alternatively* or *in combination,* a *sufficient vacuum state above the working liquid accompanied by induction of gaseous cavitation induced by nuclear particles such as neutrons* or *via use of lasers* or *acoustic horns can be used to reduce the dissolved gas content in the working liquid to limit unwanted gas cushioning." See page* 17, last *paragraph.*

Following degassing of the working liquid, the liquid is tensioned and nucleation of vapor cavities followed by implosion of the same can be initiated. Tensioning the liquid can be provided by a *variety of methods, including an acoustical wave source, an electrostrictive (piezoelectric) source,* a *magnetostrictive source,* a *centrifugal source,* a *focused (pulsed) acoustic energy* or a *venturi based system. Preferably, when an acoustical wave source is used, the acoustical wave source includes an acoustical focusing device, such as* a *parabolic-type reflector* or a *resonant cavity to intensify the acoustic pressure. See page* 17, *last paragraph.*

The appellent respectfully submits that the degassing step is an *optional* step to enhance the operation of the method or apparatus even as stated in the above by the examiner:

> "To minimize the effect of gas cushioning during implosive collapse, the working liquid *can* be degassed, a priori." (emphasis provided)

For example there is no need to de-gass a liquid that is already substantially free of gas.

The applicant therefore respectfully submits that the claim as amended is consistent with the original disclosure which is enabling.

7. In Claim 44, whether the recitation of "said fundamental particles" in lines 1 and 2 results in an insufficient antecedent basis for this claim.

The appellant has amended the claim to be consistent and submits that as amended it is now with claim 34.

8. In claim 46, whether the term "high accommodation coefficient liquid" is a relative term which renders the claim indefinite. As the term "high" which is not defined by the claim, and the specification does not provide a standard for ascertaining the requisite degree, whether one of ordinary skill in the art would not be reasonably apprised of the scope of the invention.

The appellent respectfully submits that the specification makes clear what high and low mean. High accommodation coefficient is stated to be ~1.0 (the maximum) the value associated with organic liquids such as acetone, benzene, tetrachloroethylene whereas, low is stated to be closer to 0 citing the value for water at ~ 0.07 which is not recommended for enhanced fusion induction capability. See for example Specification as filed for experimental results page 16 lines 8-20 and validating theoretical foundations Page 70 lines 14-20, Page71 lines 1-8.

Moreover, the background art has definitions for high accommodation liquids accessible to those with ordinary skill in the art for example. Reference 25 in the IDS of 2003 .

Comparison -Margulis and Lipson with the present invention 10/692,755 for 102/103 rejections

Table I:102/103 rejections COMPARISON: 10/692,755 vs Margulis & Lipson		
Claim	**10/692,755**	**Margulis (M) & Lipson (L)**
Operability of invention is demonstrated?	Yes. Evidence presented of operability in major scientific journals per IDS filings.	No. There is no evidence of operability of claims for neither (M) nor (L).
Independently replicated per teachings of application by practitioners with ordinary skill?	Yes. Three signed affidavits submitted, preceded by corresponding technical papers submitted in an IDS.	No.
Independent Claims 34, 47 System on Enablement regarding the material to be fused and environment of the system	ENABLED by D and/or T atoms which are in molecules of vapor of working liquid itself and are located within a resonant acoustic chamber (with transducers positioned outside of the liquid on outside of chamber walls). No deliberate injection or saturation with externally added D and/or T gas and no need for electric field.	**(L)** ENABLED BY Acoustic horn metal tip(s) dipped into D/T hydrogen gas filled liquid Or **(M)** ENABLED BY transducers dipped into liquid and injecting gas bubbles with D,T saturating parent liquid and with the requirement of a constant electric field in the chamber
Independent Claims 34, 47 on Mode of acoustic energy delivery and Control	ENABLED by Co-ordinated, synchronized acoustically induced tension metastability together with incident MeV scale nuclear particles. Delivery of acoustic energy externally to liquid via container only, not to liquid directly.	**(L)** Use Acoustic horn metal tip(s) & **(M)** provide acoustic to liquid; energy imparted to gas-filled bubble(s); NO teaching of use of synchronized external or internal nuclear particles
Claims 34,42: Method for Timing for Generation of and Number of bubbles	ENABLED by Cluster of several hundred liquid molecule vapor bubbles formed on-demand and synchronized in time with the acoustic tension field by known flux of incident neutrons or other stated nuclear particles per Specification.	ENABLED either with randomly evolved pre-dissolved D/T gas from liquid (L) or Deliberately inserted D-T gas bubbles along with Noble Gas (Xe) to saturate liquid by dissolved D/T gas in liquid (M).
Claim 42: Location of bubble(s)	Away from solid liquid interfaces Interior of working liquid	On the solid/liquid interfaces. NOT in interior of working liquid.
Claims 34,42,44: Time-synchronization of acoustic waves with neutron or alpha based nucleation of tensioned liquid?	Yes.	No

Claims 34, 47, (48) Non-condensible gas content of bubbles	Substantially free of gas ~0% gas content desired Specification. Explicitly degassed liquid(claim 48)	~100% (No effort or teaching to degas the liquid)
Claim 47: Liquid Type in terms of accommodation coefficient.	High (~ 1.0) accommodation coefficient type – water or liquid metals.	No such specification or teaching. Cited liquids of L and M are Low (~0.1) accommodation coefficient type – such as water or liquid metals.
Claim 34, 42: External Neutron or pre-dissolved alpha emitter based nucleation of bubbles?	Yes.	Impossible. Fusion neutrons, if generated occur when the liquid is in state of compression and as such it is impossible to use the neutrons from D-D or D-T fusion to nucleate bubbles.
Claim 34, 42: Time-span of bubbles in reaction chamber	Highly Transient; Bubbles are <u>formed on-demand</u> and are vapor (not gas) filled which re-condense within milliseconds as per teaching.	<u>Indefinite and continuous life</u>; bubbles in reaction chamber are deliberately left there till the D and/or T atoms are depleted.

9. In claims 34, 35, 37-40, 44, 45, whether under 35 U.S.C. 102(b) are anticipated by Margulis (RU 2096934)

The examiner argues:

- As to claims 34, 35, 37-40, 44 and 45, Margulis discloses a method for generation of high-temperature plasma and generating thermonuclear reactions by providing a liquid enriched with a mixture of deuterium and tritium, creating tension microbubbles containing such mixture by ultrasonic vibrations and thereby generating thermonuclear reactions.
- Applicant has not defined which portion of the working liquid is placed in a maximum tension below the cavitation threshold. Absent such definition, the examiner interprets the term broadly and reads it on any and all portions of the working liquid.
- Accordingly, one can always find a portion of the liquid in Margulis that has such maximum tension below the cavitation threshold.
- As to the claimed "nucleating agents", the thermonuclear reactions in Margulis inherently produce at least neutrons and photons, and these are inherently directed to the tensioned liquid because said particles and said liquid are in the same contained volume of the apparatus.
- As to the bubbles being substantially filled with vapor, applicant has not defined the term substantially filled, and the examiner interprets this term broadly to read on any degree of filling that occupies most of the internal volume of a bubble.
- One can always find a plurality of bubbles in Margulis that is mostly filled with vapor because of the heat produced from the thermonuclear reaction .
- As to the growing of the bubbles and the temperature generated from the system, note page 6, last 2 lines in the English language translation of Margulis.

The appellent respectfully submits that there are fundamental differences between Margulis and the present invention as claimed in Claim 34 and its dependant claims:

i. Margulis requires a liquid under *positive pressure* for their reactions – it is a compressed liquid. Margulis *requires gas insertion* into the liquid for their process. Nowhere in Margulis is there reference to tensioned liquids. (Tensioned liquids have an absolute pressure of less than zero). In fact tensioned fluids cannot support the required seeding of D and/or T enriched and saturated gas bubbles together an inert gas, required for operation of Margulis. In contrast, the present invention requires a tension state as stated in claim 34, but no gas bubbles as required by Margulis.

ii. Margulis is ***enabled** by the introduction of gas bubbles containing D and/or T atoms and an inert gas* to saturate the parent fluid in a constant electric field. The present invention *introduces the target D and/or T atoms by vaporizing the parent liquid.* There is no enablement requirement with gas bubbles in the present invention. Claim 34 and its dependants clearly state the working liquid to be enriched with D and/or T atoms and does not depend on any inserted gases nor the presence of an externally imposed electric field.

iii. Margulis with the gas saturated fluid cannot sustain a tension state. The background art is replete with examples of foaming of liquids saturated with gas as an inherent limitation for tensioning. For example consider the analogy of a gas saturated soda bottle that is opened to atmospheric pressure. Therefore the requirement of a tensioned liquid is not possible in Margulis. Therefore, *tension* micro-bubbles cannot be formed in Margulis. Therefore, for Margulis, even if nucleating particles are present, considering that a tension state is not attained, the conditions for these particles to initiate cavitation bubbles in a tension state in the liquid will clearly not be met.

iv. If thermo-nuclear fusion occurs in Margulis, then neutrons produced will be when the gas bubbles are compressed therefore the liquid will be under positive pressure and not tension. In present invention, a cluster of several hundred highly transient liquid molecule vapor bubbles are formed on-demand synchronized in time with the acoustic tension field by known (external to system) flux of incident neutrons or other stated nuclear particles per Specification. Therefore there is no parallel between the present invention and Margulis on the nucleating agents.

v. If thermonuclear fusion occurs in Margulis, then it is true that there will be soon thereafter, rise in the temperature in the predominantly gas bubble. However, there is *no possibility* of the bubbles being substantially filled with vapor *before* such a thermonuclear fusion reaction occurs – if such a reaction were to occur in Margulis. The bubbles in Margulis are by design filled with a D and/or T enriched gas unrelated to the liquid.

The appelent submits therefore that claim 34, 35, 37-40, 45 are not anticipated by Margulis and should be allowed.

10. In claim 36, whether under 35 U.S.C. 102(b) are anticipated by Margulis (RU 2096934) with regard to heat exchangers.

The appellent respectfully submits that there are fundamental differences between Margulis and the present invention as claimed in Claim 36:

Margulis uses two heat exchangers. The first to *heat* the liquid and the second to convect away heat created from a possible thermonuclear reaction by neutrons penetrating a blanket. In contrast the present invention *cools* the liquid to below an ambient temperature as noted in claim 36.

The applicant submits therefore that claim 36 is not anticipated by Margulis on this factor as well.

11. In claims 42 whether under 35 U.S.C. 102(b) are anticipated by Margulis (RU 2096934)

The appellant respectfully submits that there are fundamental differences between Margulis and the present invention as claimed in Claim 42:

The appellant respectfully submits that in Margulis, if neutrons are produced with a possible thermo-nuclear reaction, such neutrons are available only under positive pressure and therefore cannot nucleate bubbles. In contrast with the present invention where the neutrons are utilized during a tension phase of the process. Therefore Margulis does not read on the present invention on this factor as well.

12. In claims 34, 35, 37-40, 44, 45 whether under 35 U.S.C. 102(b) are anticipated by Lipson et ai., "Initiation of fusion reactions in media containing deuterium by cavitation," Soviet Physics: Technical Physics 37 (1992).

The examiner states in support of rejection of claims 34-40,42,44 and 45:

- As to claims 34,35,37-40,44, and 45, Lipson et al., disclose a method for creating fusion reactions in media containing deuterium by cavitation. (As to the interpretation of the undefined terms in applicant's claim, the discussion above relating to Margulis applies also to Lipson et al.).

- As to the nucleating agents, Lipson et al. discloses the generation of neutrons (see page 1191, col. 2, last paragraph)

- As to tensioning of the liquid below the cavitation threshold, growth of the bubbles and their collapse, see page 1190, bottom of col. 1 and top of col. 2.

The appellant respectfully submits that there are fundamental differences between Lipson and the present invention as claimed in Claims 34, 35, 37-40,44 and 45:

i. Lipson *is enabled* by a vibrating metal projection within a liquid enriched with D, wherein the metal can absorb the D. the present invention does not require such metal protrusions and the claims noted by the examiner have no reference to such metal protrusions.
ii. Lipson states (pp1191 last para): "It follows that assumptions 1 and 2 regarding the possible generation of neutrons during the collapse of cavitation bubbles, either directly in the D_2O or on the metal surface of the vibrator, *find no support from these results*". (Emphasis provided) The disclosure by Lipson therefore does not support the examiner's claim.
iii. Lipson speculates that there may be conditions for neutron emission during the growth and collapse of cavitation bubbles in D2O *enabled by* the metal surface of the protrusion or vibrator. The preset invention does not require a metal vibrator.
iv. In Lipson the liquid with cavitation bubbles are at positive pressures and not in a tension state of the liquid as in the present invention.

The appellent submits therefore that claims 34, 35, 37-40, 44, 45 are not anticipated by Lipson. The applicant respectfully submits that this claim should therefore be allowed.

13. In claims 36 whether under 35 U.S.C. 102(b) are anticipated by Lipson et al., "Initiation of fusion reactions in media containing deuterium by cavitation," Soviet Physics: Technical Physics 37 (1992).

The examiner argues that: As to claim 36, Lipson et al. disclose a cooled vessel (see page 1190, col. 2, "Experimental Apparatus and Procedure".

The appellant submits that Lipson uses a temperature of 30 C ±10 C and cools his apparatus to this range. The present invention may be cooled below ambient as claimed. Any scientific apparatus may be cooled to a required range of optimal performance. The fact that both

apparatus are cooled to their respective optimal temperature ranges does not imply that the present invention reads on Lipson or for that matter any other cooled apparatus.

The appellant submits therefore that claim 36 is not anticipated by Lipson.

14. In claims 42 whether under 35 U.S.C. 102(b) are anticipated by Lipson et al., "Initiation of fusion reactions in media containing deuterium by cavitation," Soviet Physics: Technical Physics 37 (1992) .

The examiner argues that as to claim 42, applicant's claim language, "neutron source" reads on the fusion reactions in Lipson et al. that inherently produce neutrons.

The appellant submits that that if Lipson results in a Fusion reaction the neutrons emitted would be available at a time _after_ it has utility in creating cavitation as in the present invention.

The appellant submits therefore that claims42 is not anticipated by Lipson.

15. Whether claim 41, is patentable over either Margulis or Lipson.

The examiner states in support of rejection of claim 41:

> *Claim 41 is rejected under 35 U.S.C. 103(a) as being unpatentable over either one of Margulis or Lipson et al. The size of the bubble is a parameter that depends upon specific design constraints for the system, e.g., the desired energy density of the bubbles (see page 5 of the English language translation of Margulis). Thus, it would have been obvious to modify Margulis or Lipson et al. where an application requires the claimed size of the nucleated bubbles. Such modification would have been within the knowledge and capability of one of ordinary skill in the art at the time of the claimed invention.*

The appellant respectfully submits that even if it were proper to combine background art where there is no prior art teaching for their combination, no combination of Margulis and Lipson can replicate the present invention as Margulis is *enabled* with gas bubbles inserted into an

unrelated liquid and Lipson is *enabled* with a metal vibrator or protrusion in the fluid, *neither of which are required for the present invention.*

Moreover, *even if these enablement requirements for Margulis and Lipson were not present,* the methods of both Lipson and Margulis use intentionally gas saturated liquids that result in foaming. Such foaming is governed by the ambient pressures that limit bubble size and simply produce more bubbles of the same size. In contrast the present invention utilizes the tensioned state of the liquid to stretch and grow the nuclear particle seeded bubbles to the required sizes. Therefore the conditions of neither Lipson nor Margulis allow for the growth of bubbles.

The appellant respectfully submits that this claim should therefore be allowed.

16. Whether claim 43 and 46, are patentable over either Margulis or Lipson, In light of Didenko et al.

The examiner states in support of rejection of claims 43 and 46:

> *Claim 43 and 46 are rejected under 35 U.S.C. 103(a) as being unpatentable over either one of Margulis or Lipson et al. in view of Didenko et al. (Nature 418,7/25/02). Margulis or Lipson et al. disclose(s) the applicant's claims except for the organic liquid. Didenko et al. teach that organic liquids are advantageous for processes involving cavitation because of their very low volatility (see page 4, last full paragraph).*
>
> *Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the method, as disclosed by Margulis or Lipson et al., by the teaching of Didenko et ai., to use organic liquids (which have high accommodation coefficients) for the cavitation liquid, to gain the advantages thereof (i.e., low volatility), because such modification is no more than the use of a well known expedient within the art.*

The appellant respectfully submits that even if it were proper to combine background art where there is no prior art teaching for their combination, no combination of Margulis and Didenko or Lipson and Didenko anticipate the present invention.

iii. Margulis is *enabled* with gas bubbles inserted into an unrelated liquid. Using an organic liquid as recommended by Didenko does not remove the enablement requirement of Margulis.

iv. Lipson is *enabled* with a metal vibrator or protrusion in the fluid. Using an organic liquid as recommended by Didenko does not remove the enablement requirement of Lipson.

v. Didenko (July 2002) is preceded by the priority dates of the present application and is therefore not an item of background art (or prior art).

The applicant respectfully submits that these claims should therefore be allowed.

17. Whether the duplicate claim 34 vs 44 can be overcome with the proposed amendment.

The appellant submits an amendment to remove this duplicate claim.

18. Whether Claim 47 is rejected as directed to a non-elected invention.

The appellant has amended the claim to be a method claim and therefore within the elected species.

(J) Claims appendix page(s);

Claims:

1. A nuclear fusion reactor, comprising: a) a reactor chamber for holding a working liquid molecules, said working liquid molecules including at least two nuclei of heavy isotopes of hydrogen; b) structure for placing at least a portion of said liquid into a tension state, said tension state being below a cavitation threshold of said liquid, said tension state imparting stored energy into said liquid portion; c) a nuclear cavitation initiation source for nucleation of at least one bubble from said tension liquid, said bubble having as an nucleated bubble radius being greater than a critical bubble radius of said liquid; d) a pressure field source of growing said as nucleated bubble to form at least one expanded bubble; and e) a pressure field for imploding said expanded bubble, wherein following implosion of said expanded bubble a resulting temperature sufficient to induce at least one nuclear fusion reaction is provided to said liquid.

2. The reactor of claim 1, wherein said structure for placing said liquid under tension comprises and acoustical wave source.

3. The reactor of claim 1, wherein said structure for placing said liquid under tension comprises an acoustical wave source.

4. The reactor of claim 2, wherein said acoustical wave source includes an acoustical wave focusing device.

5. The reactor of claim 1, wherein said structure for placing said liquid under tension comprises at least one centrifugal source.

6. The reactor of claim 1, wherein said structure for placing said liquid under tension comprises at least one magnetrostrictive source.

7. The reactor of claim 1, wherein said structure for placing said liquid under tension comprises at least one piezoelectric source.

8. The reactor of claim 1, wherein said nucleated bubble radius is less than 100 nm.

9 . The reactor of claim 1, wherein a ratio of a maximum radius of said expanded bubbles divided by said nucleated bubble radius is at least 105.

10. The reactor of claim 1, wherein said nuclear source comprises at least one selected from the group consisting of alpha emitters, neutron sources and fission fragments.

11. The reactor of claim 1, wherein said nuclear source comprises a neutron source.

12 . The reactor of claim 11, wherein said neutron source is an isotopic source having at least one shutter, said shutter opened to synchronize neutron impact with location in said liquid when said liquid is at a predetermined liquid tension level.

13. The reactor of claim 1, wherein said nuclear source comprises an alpha particle source.

14. The reactor of claim 13, wherein said alpha particle source is dissolved in said liquid.

15. The reactor of claim 1, wherein said liquid comprises deuterated acetone.

16. The reactor of claim 1, wherein said reactor further includes a controller for synchronizing delivery of at least one cavitation signal from said cavitation initiation source at a predetermined location in said liquid.

17. The reactor of claim 1, further comprising a structure for cooling said liquid to a temperature below an ambient temperature.

18. The reactor of claim 1, wherein said fusion reaction generates at least one of tritium and neutrons.

19. The reactor of claim 1, further comprising at least one external constraint for restraining said liquid.

20. A nuclear fusion-based electrical power plant, comprising: a) a reactor chamber for holding a working liquid; said working liquid molecules including at least two nuclei of heavy isotopes of hydrogen; b) structure for placing at least a portion of said working liquid into a tension state, said tension state being below a cavitation threshold of said liquid, said tension state imparting stored energy into said liquid portion; c) a nuclear cavitation initiation source for nucleation of at least one bubble from said tension liquid, said bubble having an as nucleated bubble radius

being greater than a critical bubble radius of said liquid; d) a pressure field source for growing said as nucleated bubble to form at least one expanded bubble; e) a pressure field for imploding said expanded bubble, wherein following implosion of said bubble a resulting temperature sufficient to induce at least one nuclear fusion reaction is provided to said liquid, and f) structure for converting energy released from said fusion reaction to electrical energy.

21. A nuclear fusion-based projectile launcher, comprising: a) a reactor chamber for holding a working liquid molecules, said working liquid molecules including at least two nuclei of heavy isotopes of hydrogen; b) structure for placing at least a portion of said working liquid into a tension state, said tension state being below a cavitation threshold of said liquid, said tension state imparting stored energy into said liquid portion; c) a nuclear cavitation initiation source for nucleation of at least one bubble from said tensioned liquid, said bubbles having an as nucleated bubble radius being greater than a critical bubble radius of said liquid; said bubbles a resulting temperature sufficient to induce at least one nuclear fusion reaction is provided to said liquid, and d) a movable constraint bounding said reaction chamber for transferring energy from said fusion reaction to propel a projectile. e) a pressure field for imploding said expanded bubble, wherein following implosion of said bubble a resulting temperature sufficient to induce at least one nuclear fusion reaction is provided to said liquid, and f) a movable constraint bounding said reaction chamber for transferring energy from said fusion reaction to propel a projectile.

22. A method for producing nuclear fusion, comprising the steps of: a) placing working liquid molecules into a tension state, said working liquid molecules including at least two nuclei of heavy isotopes of hydrogen, said tension state being below the cavitation threshold of said working liquid, said tension state imparting stored energy into said working liquid; b) cavitating at least a portion of said tensioned liquid with nuclear particles sufficient to bubble nucleate at least one bubble, said bubble having an as nucleated bubble radius greater than a critical bubble radius of said liquid; c) growing said as nucleated bubble to form at least one expanded bubble using a pressure field; and d) imploding said expanded bubble, wherein a resulting temperature from said implosion is sufficient to induce a nuclear fusion reaction involving said liquid.

23. The method of claim 22, wherein said fusion reaction is a D-D reaction or a D-T reaction.

24. The method of claim 22, further comprising the step of degassing said liquid.

25. The method of claim 22, further comprising the step of cooling said liquid to a temperature below an ambient temperature.

26. The method of claim 22, wherein a centrifugal source is used for said tensioning.

27. The method of claim 22, wherein an acoustical wave source is used for said tensioning.

28.The method of claim 27, further comprising the step of focusing acoustical waves provided by said acoustical wave source.

29 . The method of claim 22, wherein said as nucleated bubble radius is less than 100 nm.

30 . The method of claim 22, wherein a ratio of a maximum radius of said expanded bubbles divided by said as nucleated bubble radius is at least 105.

31 . The method of claim 22, wherein a neutron source is used for generating neutrons, further comprising the step of synchronizing neutron impact with a location in said working liquid having a predetermined liquid tension level.

32 . The method of claim 22, further comprising the step of synchronizing delivery of at least one cavitation initiation signal with a desired tension level in said liquid.

33 . The method of claim 23, wherein said liquid comprises deuterated acetone.

34. A method for producing thermonuclear nuclear fusion, comprising the steps of: providing a working liquid enriched with molecules comprising isotopic D or T atoms ; placing at least a portion of said liquid into a tension state, a maximum tension in said tension state being below the cavitation threshold of said liquid, said tension state imparting stored mechanical energy into said liquid portion; directing fundamental particles , at said liquid portion when said liquid portion is in said tension state, said nucleating agents having sufficient energy for nucleating a plurality of bubbles substantially filled with vapor from said liquid, said bubbles substantially filled with vapor having an as nucleated bubble radius greater than a critical bubble radius of said liquid; growing said bubbles; and imploding said bubbles substantially filled with vapor, wherein a resulting temperature obtained from energy released from said implosion is sufficient to induce a nuclear fusion reaction of said isotopic D or T atom comprising molecules in said liquid portion.

35. The method of claim 34, wherein said thermonuclear fusion reaction is a D-D reaction or a D-T reaction.

36. The method of claim 34, further comprising the step of cooling said liquid to a temperature below an ambient temperature.

37. The method of claim 34, wherein said tension state is a part of a time-varying pressure state including compressive and tensile portions.

38. The method of claim 34, wherein said tension state is a constant tension state.

39. The method of claim 34, wherein an acoustical wave source is used for said tensioning.

40. The method of claim 39, further comprising the step of focusing acoustical waves provided by said acoustical wave source.

41. The method of claim 34, wherein said as nucleated bubble radius is from 10 to 100 nm.

42. The method of claim 34, wherein a neutron source is used for said nucleating, further comprising the step of synchronizing neutron impact with a location in said liquid, having a predetermined liquid tension level.

43. The method of claim 34, wherein said liquid is an organic liquid.

44. The method of claim 34, wherein said fundamental particles are selected from the group consisting of alpha particles, neutrons and fission fragments.

45. The method of claim 34, wherein said growing and imploding occurs responsive to an applied acoustical field.

46. The method of claim 34, wherein said liquid is a high accommodation coefficient liquid.

47. A method for producing thermonuclear fusion, comprising the steps of : filling a chamber with a high accommodation coefficient liquid; inducing tension in said high accommodation coefficient liquid; directing a nucleating agent comprising at least one of: neutrons, alpha particles, photons and fission products to said chamber; enhancing the size of the nucleated bubbles in tension to a volume greater than a predetermined volume before inducing controlled implosion; thereby producing thermonuclear fusion.

48. A method of claim 34, wherein the working liquid is de-gassed prior to being put in a tension state.

(K) Evidence appendix pages

Statement of Dr. Yiban Xu

This affidavit is being supplied to state that if called upon, I, Yiban Xu would be competent to confirm as to the accuracy of the following in relation to the experiments on bubble (sono) fusion that I have conducted or participated in:

1. I am making this statement of my own personal knowledge and of my own free will. All of the facts contained in this statement are true.
2. I obtained my PhD in Nuclear Engineering from Purdue University in 2004.
3. The bubble fusion test cell apparatus used for my independent confirmatory studies (Xu et al., 2005) was based on the teachings and design information of the invention document entitled "Methods and Apparatus to Induce D-D and D-T Reactions – Co-inventors: Rusi P. Taleyarkhan and Colin D. West; US Patent and Trademark Office (USPTO) Application 10/692,755, Filing Date Oct. 27, 2003, Pub.Date: Jun.23, 2005" also used by the Taleyarkhan et al. team as reported in their published papers (Taleyarkhan et al., 2002; Taleyarkhan et al., 2004; Taleyarkhan et al.; 2006).
4. There was no intentional effort to dissolve gases into the test liquid prior to conducting bubble fusion experiments but degassing was conducted per teachings of USPTO 10,692,755.
5. Control experiments were systematically conducted changing only one parameter at a time. This was done to ensure that thermonuclear bubble fusion signals (neutrons and/or tritium) were generated only when the test liquid was deuterated, and when it was undergoing nuclear particle based cavitation with spherically imploding bubble clusters per teachings of USPTO 10,692,755 (Fig.3), all else remaining the same.
6. The well-known required signs of thermonuclear fusion (Gross, 1984) were reproducibly obtained, peer reviewed, and recorded as published in my studies. These included: emission of neutrons of ~2.45 MeV with over 11 standard deviation (SD) statistical significance as shown in Fig. 1a. The appropriateness of the measured spectral shape for my experiments as representing 2.45 MeV neutrons from nuclear fusion was also separately confirmed (Fig. 1b) with a 3-D Monte-Carlo based simulation of my experimental system using well-known and established US-federally sponsored computer codes (MCNP, 2003; Dickens, 1998) together with an independent method based on combination of the well-known MCNP code system with the actually measured and published neutron spectra for my detector type (Lee-Lee, 1998). These results are commensurate with teachings of USPTO 10/692,755 (Fig. 11).

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7. My experiments also examined for tritium as would be emitted from nuclear fusion, and it was found that the neutron emissions of para. 6 above, were reproducibly accompanied with commensurate emission of tritium with over 4 SD statistical significance (Fig. 2) when bubble implosions were spherical (Fig. 3a) versus elongated in the form of streamers (see Fig. 3b), when such fusion does not occur. When the bubble implosions were spherical (Fig. 3a) they are audible and recordable shock traces which are also accompanied with emission of light flashes (Fig. 4a) thereby, indicating hot, highly compressed conditions for my experiments as would be the case for thermonuclear fusion. Positive nuclear emissions from my experiments indicative of thermonuclear fusion were obtained reproducibly on several different days and also on within the same experimental campaign on a given day. These results are commensurate with teachings of USPTO 10/692,755 (Figs. 3, 10, 11, and 12).
8. Production of neutrons as byproducts of this method and process have significant potential utility, e.g., for interrogation of materials for non-destructive examination of molecular compounds as at airports and cement industries, for radiation therapy, for diagnosis. The same is true for tritium, a special nuclear material of significance not only for the commonly attributed use for maintaining the nuclear stockpile but more so for wide variety of industrial applications as use in airport runway lights, non-electricity based passive lighting, use as a radio-tracer and taggant for molecules in molecular biology research. The utility aspects of a neutron-tritium source are well established (see, e.g., Waltar, 2004).
9. This method of inducing D-D and D-T reactions is furthermore, distinct in that there was no acoustic horn or such vibrator that was dipped into the test liquid during conduct of my reported bubble fusion experiments. In my bubble fusion experiments of the type reported by Taleyarkhan et al. the nucleation of bubbles occurs away from solid-liquid interfaces. Acoustic energy was provided into the test liquid by use of a piezo-electric element epoxied to the outside of the glass wall.
10. In the experiments that I was involved, care was taken to ensure that there were no extraneous sources of nuclear particles that could have given rise to the bubble fusion signatures as reported for my experiments and studies (Xu et al., 2005).
11. The pressure distribution of the bubble fusion test cell (as used for my studies based on teachings of USPTO 10/692,755 produces neutron sensitive cavitation regions away from the solid-liquid interfaces. This is due to the pressure profiles which ensure that bubble nucleation takes place within the bulk of the liquid once the input power is increased above a certain level readily determined experimentally. This attribute is a

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consequence of the pressure profiles in such a design which is an aspect that I have confirmed for myself while conducting oscillating pressure mapping tests also.

12. It is a well-known fact (Gross, 1984) that conditions for D-D fusion subsume conditions for D-T fusion which are ~100 times easier to initiate.

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- Waltar, A., "Radiation and Modern Life," Publisher: Prometheus Books, Inc., 2004

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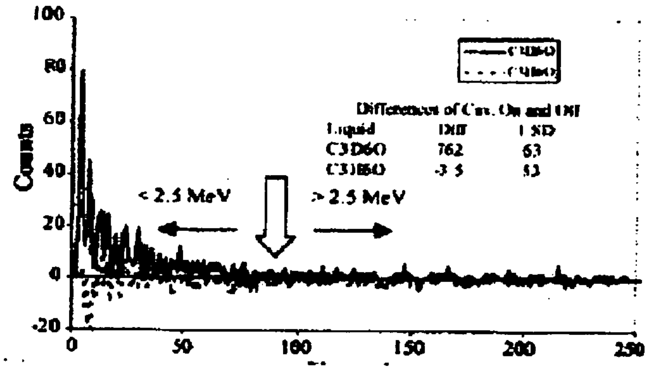

Fig. 1a: Statistically significant (over 11 standard deviations) 2.45 MeV excess neutrons from thermonuclear fusion with neutron seeded cavitation of deuterated acetone(C3D6O) and null results from control experiments with non-deuterated acetone (C3H6O) under identical conditions; confirms teachings of USPTO 10,697,755 (Fig. 11). Fig.1a is excerpted from Xu et al. (2005, *Nuclear Engineering and Design* Journal);

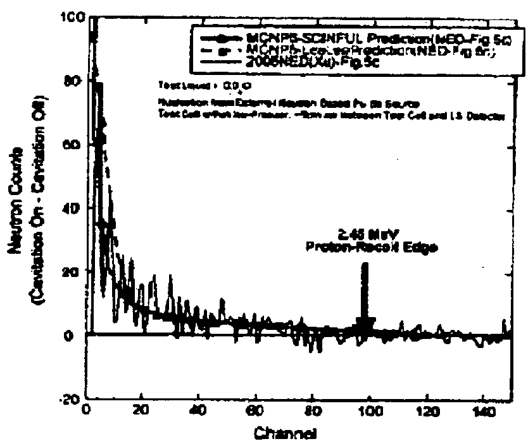

Fig.1b: Independent Numerical Affirmation of D-D Fusion 2.45 MeV neutron spectra with 3-D Monte-Carlo Computer Model simulations of Xu et. al. (2005) experiment using two independent approaches: MCNP-SCINFUL USDoE codes (Dickens, 1988; MCNP, 2003) and MCNP-LeeLee (1998) Measured NE-213 detector Predictions.

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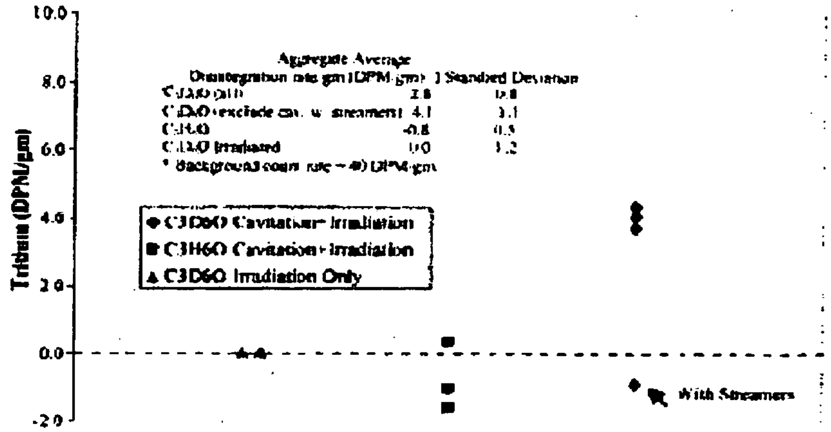

Fig. 2: Statistically significant (4 standard deviations), Reproducible, D-D nuclear fusion based tritium emission with neutron seeded cavitation of deuterated acetone with spherical imploding bubble clusters and null results for all other control experiments commensurate with teachings of USPTO 10,692,755 (Fig.10); Null results are also noted with C3D6O when bubble shapes are non-spherical (streamers); Fig.2 excerpted from Xu et al. (2005).

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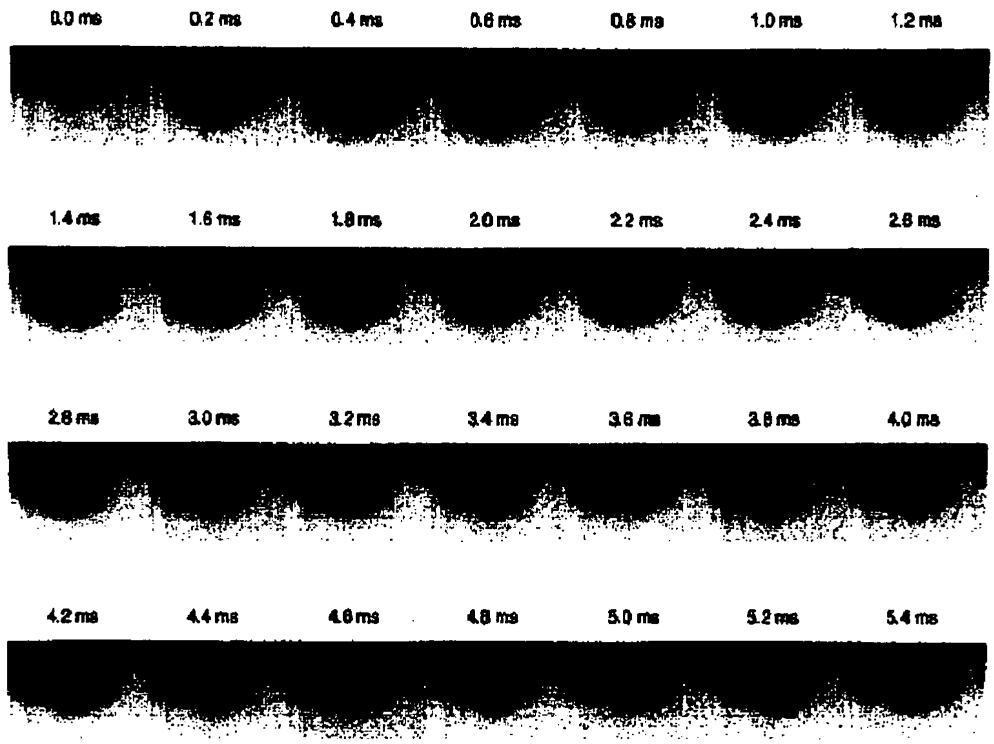

Fig. 3a: Spherical bubble cluster shapes for successful bubble fusion experiments commensurate with teachings of USPTO application 10,692,755 (Fig. 3); Fig.3a excerpted from Xu et al. (2005; *Nuclear Engineering and Design Journal*; Nuclear Reactor Thermal Hydraulics Conference, NURETH-11, 2005).

Yiban Xu [signature]; Date: 02/26/2009

Statement of Dr. Yiban Xu

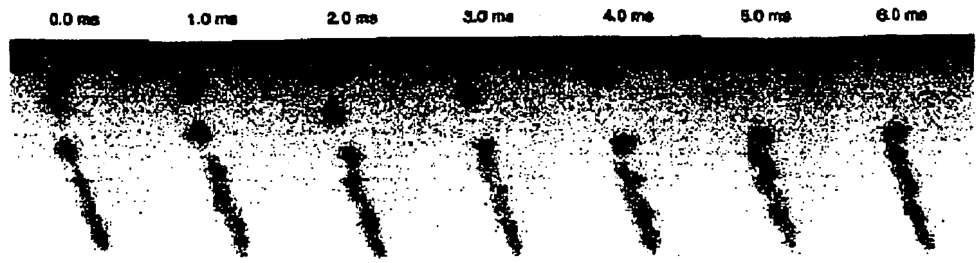

Fig. 3b: Non-Spherical elongated bubble cluster shapes resulting in unsuccessful bubble fusion experiments; Fig. 3b is excerpted from Xu et al. (2005; *Nuclear Engineering and Design* Journal, 2005; Proc. Intl. Nuclear Reactor Thermal Hydraulics Conference, NURETH-11, 2005)

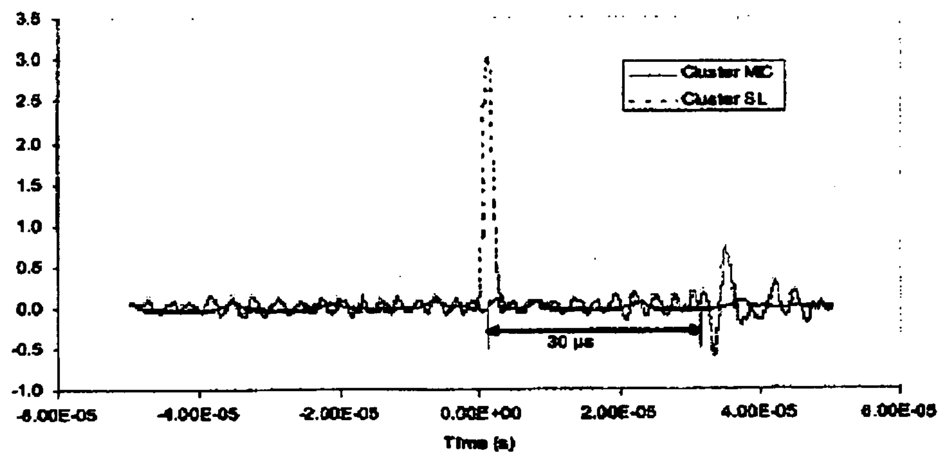

Fig. 4a: SL light flashes for spherically imploding bubbles followed by shock wave 30 µs later for spherically imploding bubbles commensurate with teachings of USPTO 10,692,755 (Fig. 3); Fig.4a is excerpted from Xu et al. (2005, NURETH-11).

Yiban Xu [signature]; Date: 02/26/2009

Statement of Dr. Yiban Xu

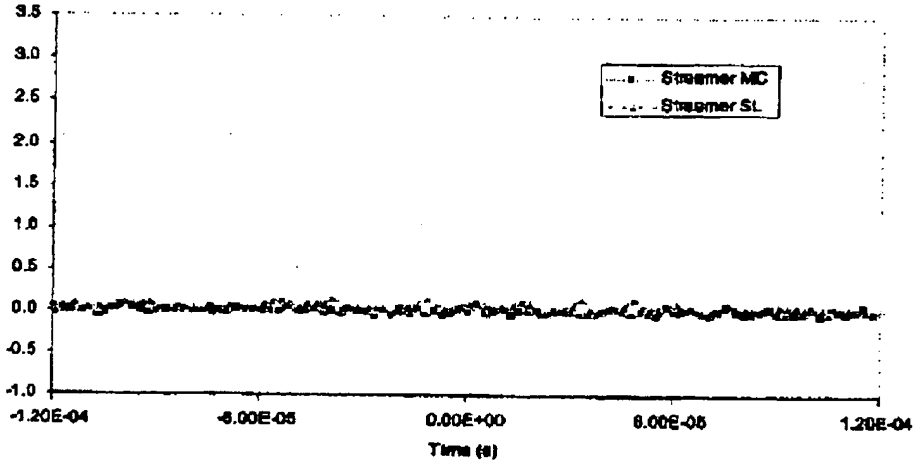

Fig. 4b: Absence of SL light flashes and shock signals for non-spherically imploding bubbles leading to unsuccessful bubble fusion, per USPTO 10,692,755; Fig. 4b is excerpted from Xu et al. (2005, NURETH-11).

Yiban Xu ______; Date: 02/26/2009

Affidavit of Dr. JaeSeon Cho

This affidavit is being supplied to state that if called upon, I, JaeSeon Cho would be competent to confirm as to the accuracy of the following in relation to the experiments on bubble (sono) fusion that I have conducted or participated in:

1. I am making this statement of my own personal knowledge and of my own free will. All of the facts contained in this statement are true.
2. I obtained my PhD in Nuclear Engineering in 1999 from Seoul National University and I currently work for FNC Tech. Inc., a high-technology company in S. Korea where I reside.
3. The bubble fusion test cell apparatus used for my studies was based on the design used by the Taleyarkhan et al. team as reported in their published papers [Taleyarkhan et al., 2002; Taleyarkhan et al., 2004; Taleyarkhan et al.; 2006]. This is true also for the apparatus in my paper (Cho et al., 2003).
4. There was no intentional effort to dissolve gases into the test liquid prior to conducting bubble fusion experiments.
5. Control experiments were conducted to ensure that bubble fusion signals (neutrons and/or tritium) were generated only when the test liquid was deuterated, and when it was undergoing nuclear particle based cavitation.
6. There was no acoustic horn or such vibrator that was dipped into the test liquid during conduct of my reported bubble fusion experiments. In my bubble fusion experiments of the type reported by Taleyarkhan et al. the nucleation of bubbles occurs away from solid-liquid interfaces. Acoustic energy was provided into the test liquid by use of a piezo-electric element epoxied to the outside of the glass wall.
7. In the experiments that I was involved, care was taken to ensure that there were no extraneous sources of nuclear particles that could have given rise to the bubble fusion signatures as reported for my experiments and studies.
8. The pressure distribution of the bubble fusion test cell as used for my studies (Cho et al., 2004) was based on the Taleyarkhan et al., 2002 design. It produces neutron sensitive regions away from the solid-liquid interfaces. This is due to the induced pressure profiles, which ensure that bubble nucleation takes place within the bulk of the liquid. This attribute is a consequence of the pressure profiles in such a design which is an aspect that I have confirmed for myself while conducting oscillating pressure mapping tests (see Figs. 2 and 6 of Cho et al., 2004). The threshold pressure for neutron based nucleation is readily determined by increasing acoustic power to the point where nuclear particle based cavitation begins.

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- Cho, J. S.,& R. P.Taleyarkhan, Proc. 10th Int. Conf. Nucl. Reac. Thermal Hydraulics, Seoul, S.Korea, October 5-9, 2003.
- Taleyarkhan, R. P., et al., Science, 295, 1868, 2002.
- Taleyarkhan, R.P., et al., Phys. Rev. E, 69, 2004.
- Taleyarkhan, R.P., et al., Phys. Rev. Ltrs., 96, 034301, 2006.

Signed: ______________

Affidavit of Professor William Bugg

This affidavit is being supplied to state that if called upon, I, William Bugg would be competent to testify as to the accuracy of the following in relation to the experiments and studies on bubble (sono) fusion that I have conducted or participated in:

1. I am making this affidavit of my own personal knowledge and of my own free will. All of the facts contained in this affidavit are true.
2. I obtained my PhD in 1959 from the University of Tennessee-Knoxville, where I served as Head of Physics from 1969 to 1996. I am a Fellow of the American Physical Society and am currently a scientific researcher at Stanford University's SLAC facility.
3. The bubble fusion test cell apparatus used for the confirmatory studies I was involved in (Bugg, 2006) was similar to that used by the Taleyarkhan et al. team as reported in their published papers (Taleyarkhan et al., 2002; Taleyarkhan et al., 2004; Taleyarkhan et al.; 2006).
4. There was no intentional effort to dissolve gases into the test liquid prior to conducting bubble fusion experiments. On the contrary the containers were initially pumped to remove gasses.
5. Control experiments were conducted to ensure that bubble fusion signals (neutrons and/or tritium) were generated only when the test liquid was deuterated, and when it was undergoing nuclear particle based cavitation.
6. There was no acoustic horn or such vibrator that was dipped into the test liquid during conduct of my bubble fusion experiments. In my bubble fusion experiments of the type reported by Taleyarkhan et al. the nucleation of bubbles occurs away from solid-liquid interfaces. Acoustic energy was provided into the test liquid by use of a piezo-electric element epoxied to the outside of the glass wall.
7. In the experiments that I was involved in, I carefully ensured the absence of external sources of neutrons (such as Californium) that could have given rise to the bubble fusion neutron emission signatures as documented in my report (Bugg, 2006).
8. For the bubble fusion confirmatory experiments that I participated in, I noted that spherically-shaped bubbles formed and imploded within the bulk of the liquid away from the walls of containers.

References Cited Above:

- Bugg, W., "Report on Activities on June 6-7 Visit.," Report to Purdue University via email attachment, June 9, 2006.
- Taleyarkhan, R. P., et al., Science, 295, 1868, 2002.
- Taleyarkhan, R.P., et al., Phys. Rev. E, 69, 2004.
- Taleyarkhan, R.P., et al., Phys. Rev. Ltrs., 96, 034301, 2006.

Signed: Wm W Bugg

Sep 25 2008 23:32 301 320 88 00 p.23

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Modeling, analysis and prediction of neutron emission spectra from acoustic cavitation bubble fusion experiments

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ABSTRACT

Self-nucleated and external neutron nucleated acoustic (bubble fusion) cavitation experiments have been modeled and analyzed for neutron spectral characteristics at the detector locations for all separate successful published bubble fusion studies. Our predictive approach was first calibrated and validated against the measured neutron spectrum emitted from a spontaneous fission source (^{252}Cf), from a Pu–Be source and from an accelerator-based monoenergetic 14.1 MeV neutrons, respectively. Three-dimensional Monte-Carlo neutron transport calculations of 2.45 MeV neutrons from imploding bubbles were conducted, using the well-known MCNP5 transport code, for the published original experimental studies of Taleyarkhan et al. [Taleyarkhan, et al., 2002. Science 295, 1868; Taleyarkhan, et al., 2004. Phys. Rev. E 69, 036109; Taleyarkhan, et al., 2006a. PRL 96, 034301; Taleyarkhan, et al., 2006b. PRL 97, 149404] as also the successful confirmation studies of Xu et al. [Xu, Y., et al., 2005. Nuclear Eng. Des. 235, 1317–1324], Forringer et al. [Forringer, E., et al., 2006a. Transaction on American Nuclear Society Conference; vol. 95, Albuquerque, NM, USA, November 15, 2006, p. 736; Forringer, E., et al., 2006b. Proceedings of the International Conference on Fusion Energy, Albuquerque, NM, USA, November 14, 2006] and Bugg [Bugg, W., 2006. Report on Activities on June 2006 Visit. Report to Purdue University, June 9, 2006]. NE-213 liquid scintillation (LS) detector response was calculated using the SCINFUL code. These were cross-checked using a separate independent approach involving weighting and convoluting MCNP5 predictions with published experimentally measured NE-213 detector neutron response curves for monoenergetic neutrons at various energies. The impact of neutron pulse-pileup during bubble fusion was verified and estimated with pulsed neutron generator based experiments and first-principle calculations. Results of modeling-cum-experimentation were found to be consistent with published experimentally observed neutron spectra for 2.45 MeV neutron emissions during acoustic cavitation (bubble) fusion experimental conditions with and without ice-pack (thermal) shielding. Calculated neutron spectra with the inclusion of ice-pack shielding are consistent with the published spectra from experiments of Taleyarkhan et al. [Taleyarkhan, et al., 2006a. PRL 96, 034301] and Xu et al. [Xu, Y., et al., 2005. Nuclear Eng. Des. 235, 1317–1324] where ice-pack shielding was present, whereas without ice-pack shielding the calculated neutron spectrum is consistent with the experimentally observed neutron spectra of Taleyarkhan et al. [Taleyarkhan, et al., 2002. Science 295, 1868; Taleyarkhan, et al., 2004. Phys. Rev. E 69, 036109] and Forringer et al. [Forringer, E., et al., 2006a. Transaction on American Nuclear Society Conference, vol. 95, Albuquerque, NM, USA, November 15, 2006, p. 736; Forringer, E., et al., 2006b. Proceedings of the International Conference on Fusion Energy, Albuquerque, NM, USA, November 14, 2006] and also that from GEANT computer code [Agostinelli, S., et al., 2003. Nuclear Instrum. Methods Phys. Res. A 506, 250–303] predictions [Naranjo, B., 2006. PRL 97 (October), 149403; in which ice shielding was also absent.

The results of this archive confirm for the record that the confusion and controversies caused from past reports [Reich, E., 2006. Nature (March) 060306. news@nature.com; Naranjo, B., 2006. PRL 97

Abbreviations: Cf, californium; Ci, Curie; D, deuterium; GEANT, a Monte-Carlo nuclear particle interaction code system; n, neutron; MCNP, Monte-Carlo N-particle computer code; NE-213, trademark of scintillation liquid from Nuclear Enterprises Inc.; LS, liquid scintillation; PNG, pulse neutron generator; PRE, proton recoil edge; PSD, pulse-shape discrimination; Pu–Be, plutonium–beryllium; SCINFUL, scintillator full response computer code; T, tritium; UN, uranyl nitrate; γ, gamma photon.

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(October) 149403] have resulted from their neglect of important details of bubble fusion experiments. Results from this paper demonstrate that ice-pack shielding between the detector and the fusion neutron source, gamma photon leakage and neutron pulse-pileup due to picosecond duration neutron pulse emission effects play important roles in affecting the spectra of neutrons from acoustic inertial confinement thermonuclear fusion experiments.

1. Introduction

In 2006, evidence was presented for a unique, new stand-alone acoustic inertial confinement fusion device that was successfully tested and results published (Taleyarkhan et al., 2006a). Those experiments were conducted with four different liquid types in which bubbles were nucleated without the use of external neutron sources. Four independent detector systems were used [a neutron track plastic detector to provide unambiguous visible records for fast neutrons, a LiI thermal neutron detector, a NE-213-type liquid scintillation (LS) detector, and a NaI gamma (γ) ray detector]. All detector systems measured statistically significant (from 6 to 20+ standard deviations) nuclear emissions for experiments with deuterated benzene and acetone mixtures but not for experiments with heavy water, a finding which validated theoretical predictions (Nigmatulin et al., 2005) of our simulations of the implosion dynamics which indicated that heavy water would not be a good choice for attaining thermonuclear fusion in imploding bubbles. The measured neutron energies from bubble fusion experiments were, as expected, substantially ≤2.45 MeV. Control experiments did not result in statistically significant neutron or γ ray emissions. These observations of neutron emissions in self-nucleated experiments with deuterated benzene–acetone mixtures but not for the controls (i.e., non-deuterated mixtures) have been successfully confirmed (Forringer et al., 2006a,b; Bugg, 2006). In the studies of Forringer et al. and Bugg, the experimental configurations they used were different from that used by Taleyarkhan et al. (2006a,b). The two experimental configurations are shown in Fig. 1a and b. As noted therein, a principle distinguishing factor between the two configurations is the presence or absence of ~3 cm of ice-pack materials acting as thermal shielding around the test cell enclosure. Whereas, in the reported experimental systems of Taleyarkhan et al. (2002, 2004, 2006a,b) the ice-pack shielding was required and present, the same was not true in the experiments conducted by Forringer et al. (2006a,b) and Bugg (2006).

The results of Taleyarkhan et al. (2006a) using the LS detector system offered the highest level of statistical significance of above 17 standard deviations (S.D.). Because of the presence of intervening ice-pack shielding, the published neutron spectrum (Taleyarkhan et al., 2006a) incorporated characteristics that were different from the shape of the neutron spectrum for a monoenergetic 2.45 MeV neutron emanating from the test cell without having to interact with ice-pack shielding. A qualitative discussion was provided (Taleyarkhan et al., 2006b) in response to questions and comments raised from code calculations for the presumed geometric configuration by Naranjo (2006) of the University of California at Los Angeles (UCLA). Unfortunately, the UCLA predictions were made for an incorrectly presumed experimental configuration (e.g., with no ice-packs) and would actually be more applicable for comparisons with the published measured neutron spectra of Forringer et al. (2006a,b) and Taleyarkhan et al. (2002, 2004) rather than those of Taleyarkhan et al. (2006a). Nevertheless, these faulty simulations seeded and caused considerable controversy and confusion (Reich, 2006; Naranjo, 2006).

In 2002 and 2004, evidence was first presented for the neutron spectrum measured during external neutron-based acoustic cavitation experiments (Taleyarkhan et al., 2002, 2004). In these experiments nucleation of bubbles in pure deuterated acetone (C_3D_6O) was achieved using a 14.1 MeV pulse neutron generator (PNG). The test geometry for this study is shown in Fig. 1d. Although the enclosure is similar to that for Fig. 1a, the LS detector was positioned to be within the enclosure as shown with no intervening ice-pack materials. The results of the 2004 studies reported by Taleyarkhan et al. (2004) were successfully confirmed in studies reported by Xu et al. (2005) in which they used a different experimental enclosure type as shown in Fig. 1c, and the bubble nucleation was conducted using randomly emitted neutrons from an isotope source. However, as for the self-nucleation bubble fusion reports of Taleyarkhan et al. (2006a,b), in the Xu et al. (2005) studies, their LS detector was also positioned outside the freezer, and as such, a ~3–4 cm of ice layer was also present between the test cell and the LS detector.

The purpose of this paper is to present a comprehensive unifying study for all the reported successful bubble fusion studies with the goal to remedy the unfortunate controversies and confusion resulting from the misguided simulations for incorrect experimental configurations as reported in the literature (Reich, 2006; Naranjo, 2006), as well as due to the omission of important effects such as pulse-pileup and gamma photon leakage. For completeness, we have conducted simulations of successful published studies not only for the self-nucleation experiments, but also, for the external neutron-based experiments.

Questions have also been raised (Reich, 2006) concerning the detection of neutron counts in channels higher than the 2.45 MeV proton recoil edge (PRE). The present paper includes results of analyses, backed up with experimental evidence, for clarifying the principle mechanisms concerning such occurrence for bubble fusion experiments.

2. Two independent modeling-simulation approaches

In order to evaluate the relative effects on the expected 2.45 MeV spectrum with and without ice-pack shielding we conducted assessments with two independent methods to obtain cross-checks and better confidence for the validity of our predictions. The first approach was to establish a simulation platform similar to that used by UCLA in which results of three-dimensional neutron transport from within the test cell were derived using the USDOE's code system MCNP5 (MCNP, 2003) at the location of the LS detector. This down scattered neutron flux profile was next combined with the USDOE's *Scintillator Full* (SCINFUL) response Monte-Carlo based code system (Dickens, 1988). SCINFUL was developed specifically for predicting the response function of neutron interactions with NE-213 detectors. The second approach we developed was to act as a cross-check to the MCNP5–SCINFUL predictions. It involves directly combining the neutron emission spectra emanating from the experimental system (as derived from MCNP5 simulations) with the published (i.e., directly measured) neutron energy-related pulse-height spectra for an actual 5 cm × 5 cm sized NE-213 detector (viz., of the same size and type as used by Taleyarkhan et al., 2002, 2004, 2006a,b; Xu et al., 2005; also by Forringer et al., 2006a,b). Predictions from both approaches could then be compared with the various published bubble fusion experimental data.

2.1. Calibration-benchmarking of LS detector with prediction methodology

The SCINFUL code requires the user to provide to it the incoming neutron energy spectrum (e.g., from a known source of neutrons of various energies). A known source could be from a National Institute of Standards and Technology (NIST)-certified isotope source or from an accelerator-based system. Alternately, it could be the prediction from a well-characterized nuclear particle transport code such as MCNP5. SCINFUL utilizes Monte-Carlo techniques and has itself been extensively benchmarked by the developers against a variety of experimental databases for its ability to predict the overall response of a NE-213 LS detector system to incoming neutrons over the energy range 0.5–80 MeV. A known shortcoming is associated with the PRE where detector resolution issues can lead to smearing-related extension of counts to higher channels in an actual detector system but this is not possible to model theoretically since it involves intricacies of individual detector construction and multidimensional issues. In order to gain confidence in the prediction methodology employed for this study it was decided to ourselves calibrate the SCINFUL code predictions for our laboratory's 5 cm × 5 cm NE-213 LS detector using the electronic component train and settings for the published bubble fusion experimental spectra. The comparisons were made for three different neutron sources. The first two were NIST-certified isotope-based neutron-gamma sources: (1) 1 Ci, Pu-Be source emitting $\sim 2 \times 10^6$ n/s; (2) $\sim$0.1 mCi, ^{252}Cf source emitting $\sim 10^5$ n/s. The second type of neutron source produced 14.1 MeV monoenergetic neutrons from an accelerator device commonly called a PNG and is based on D–T interactions. The emission rate was about 5×10^5 n/s. The NE-213 LS detector was placed ~30 cm from each of these sources and the spectra were obtained with and without

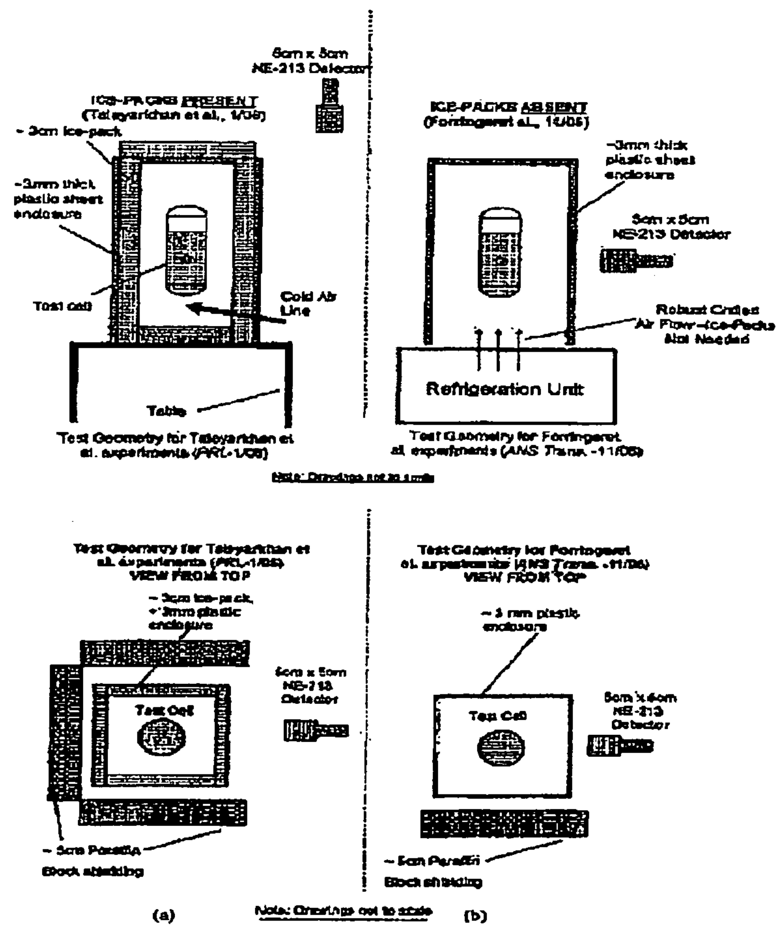
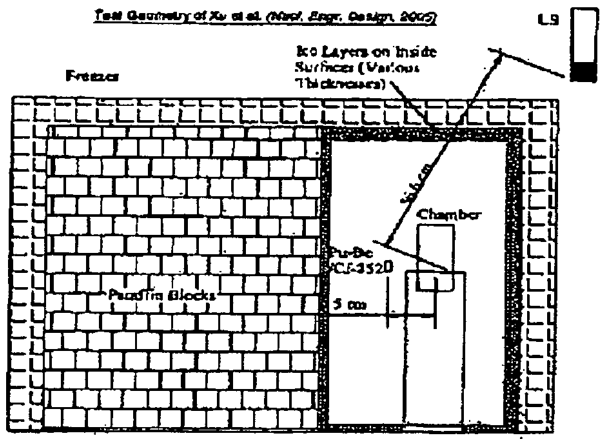


Fig. 1. Experimental geometries of (a) Taleyarkhan et al. (2006a,b) (b) Forringer et al. (2006a,b) (c) Xu et al. (2005) and (d) Taleyarkhan et al. (2002, 2004).

Test Geometry of Xu et al. (Nucl. Engr. Design, 2005)



(1c) – Xu et al. (2005)

Test Geometry for Taleyarkhan et al.(Science-3/2002; Phys.Rev.E-3/2004)